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## (54) LIFT ASSEMBLY FOR A WORK VEHICLE

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***E02F 9/26*** (2006.01)
***E02F 3/34*** (2006.01)
***E02F 3/42*** (2006.01)

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(58) **Field of Classification Search**
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See application file for complete search history.

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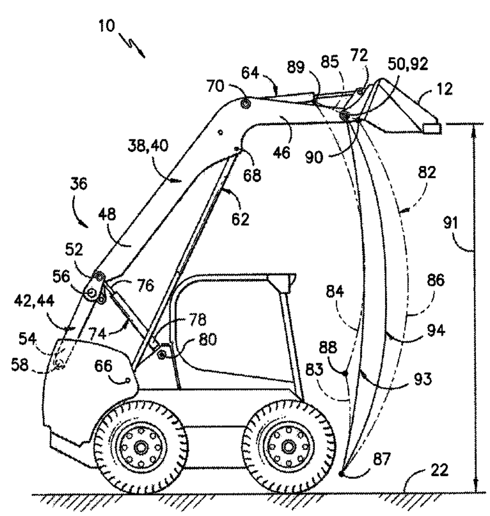
## (57) ABSTRACT

In one aspect, a lift assembly for a work vehicle may include a loader arm and a control arm extending between first and second ends. The first end may be coupled to a chassis of the vehicle at a first pivot point and the second end may be coupled to a rear end of the loader arm at a second pivot point. Additionally, the lift assembly may include a lift cylinder coupled between the loader arm and the chassis and a control cylinder extending between upper and lower ends, with the upper end being coupled the control arm and the lower end being coupled to the chassis at a third pivot point.

**17 Claims, 8 Drawing Sheets**



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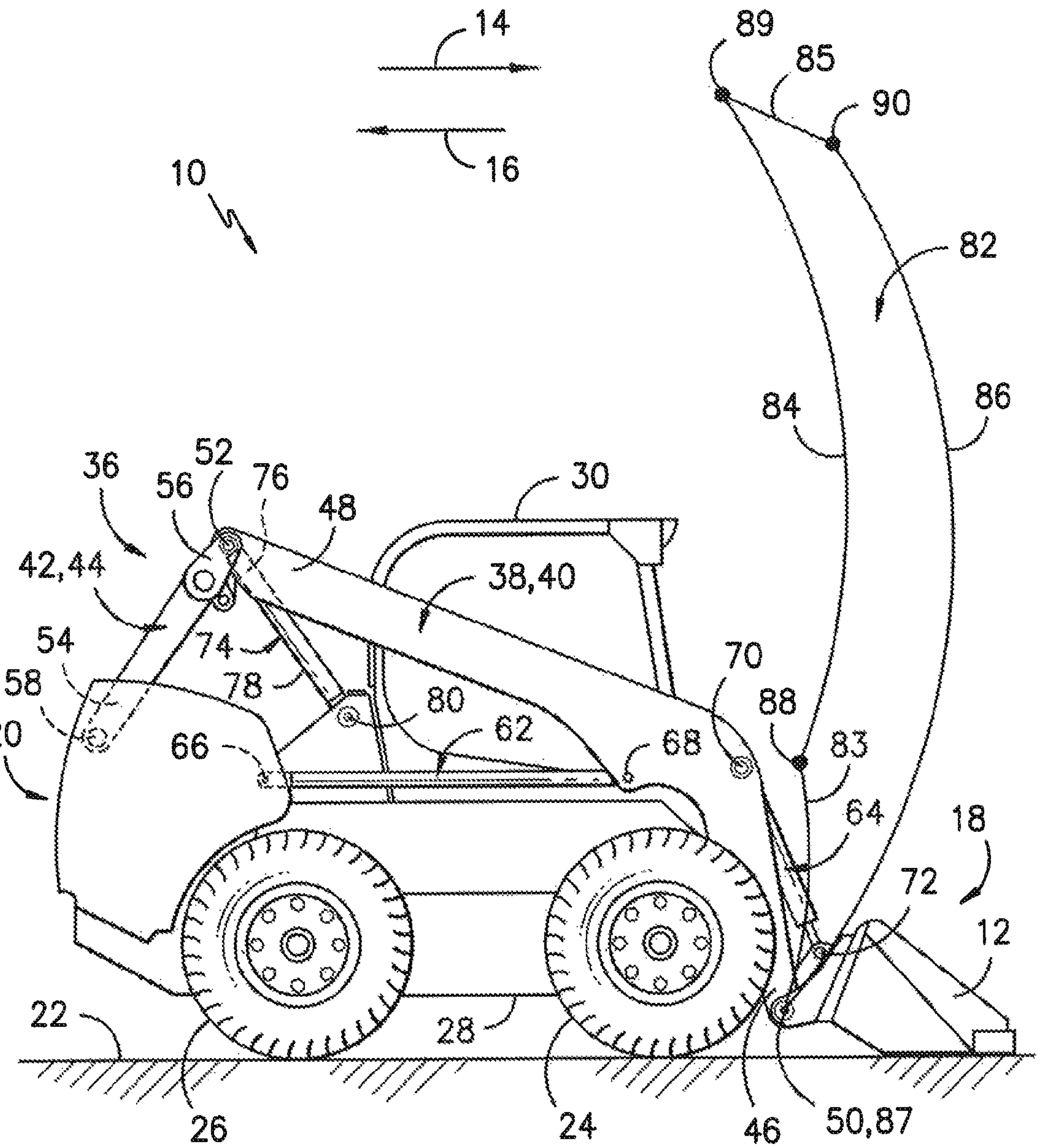
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58
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50,87

FIG. —1—

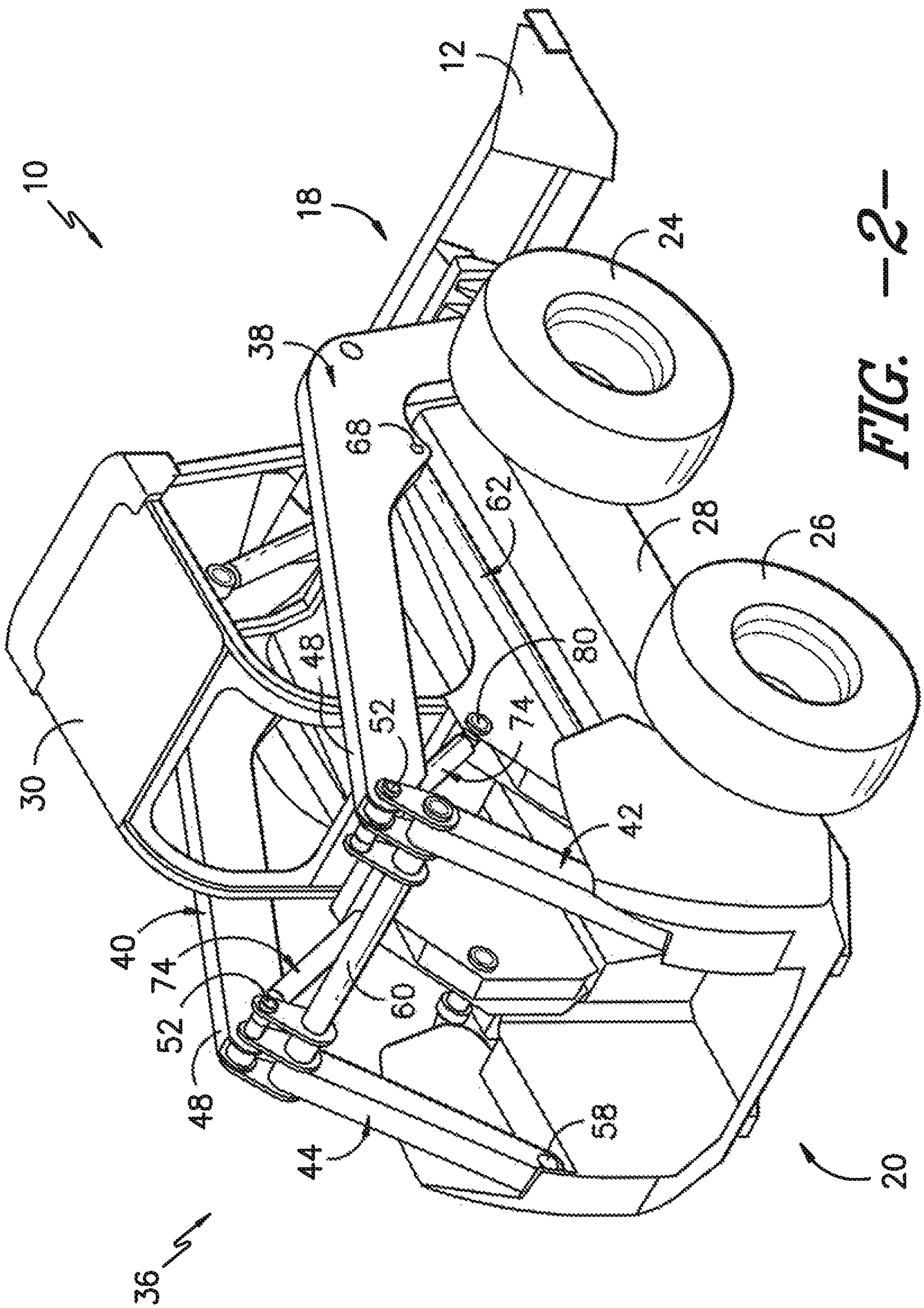
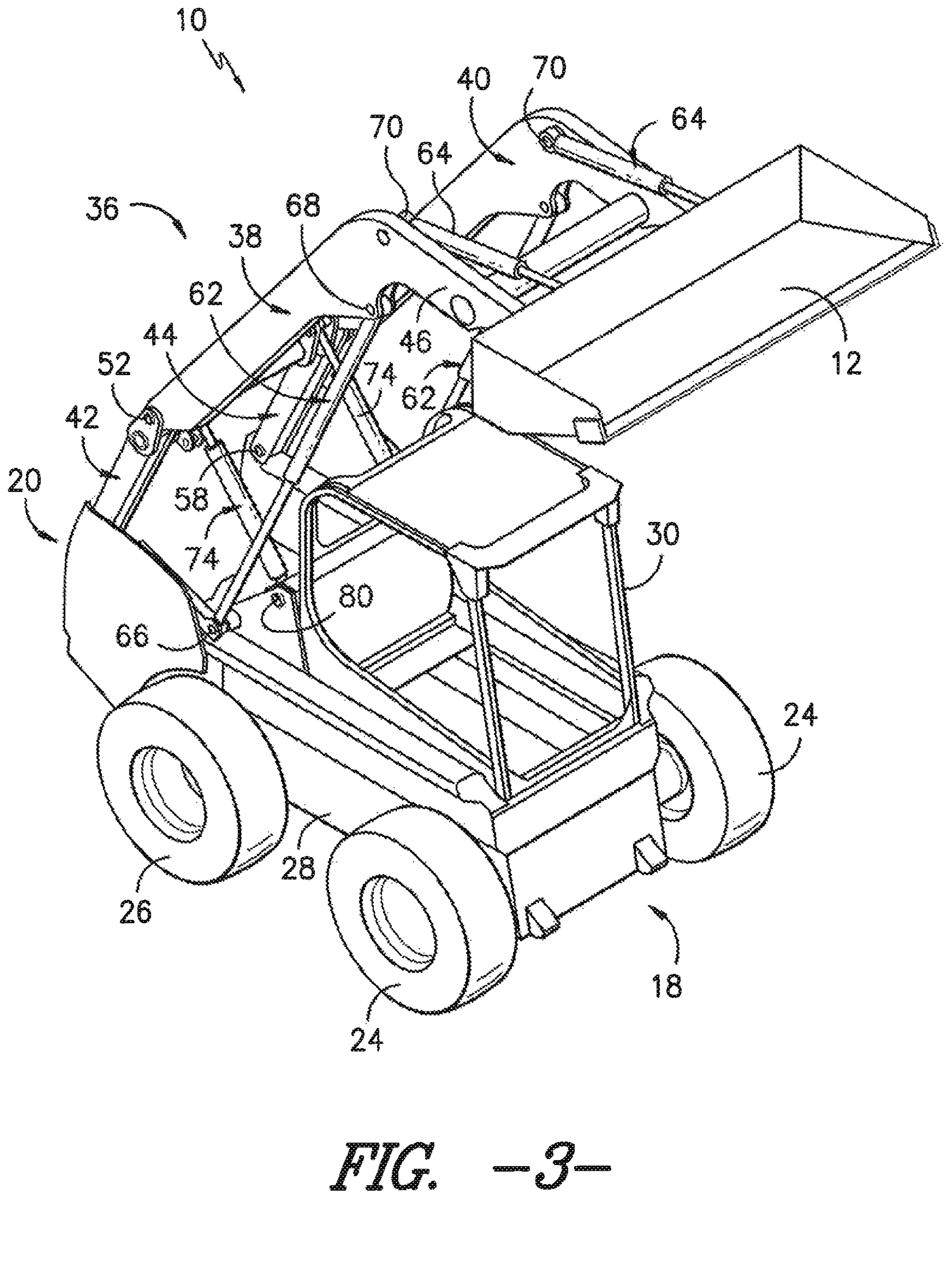



FIG. -2-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70
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70
64
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36
68
38
62
44
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74
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42
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66
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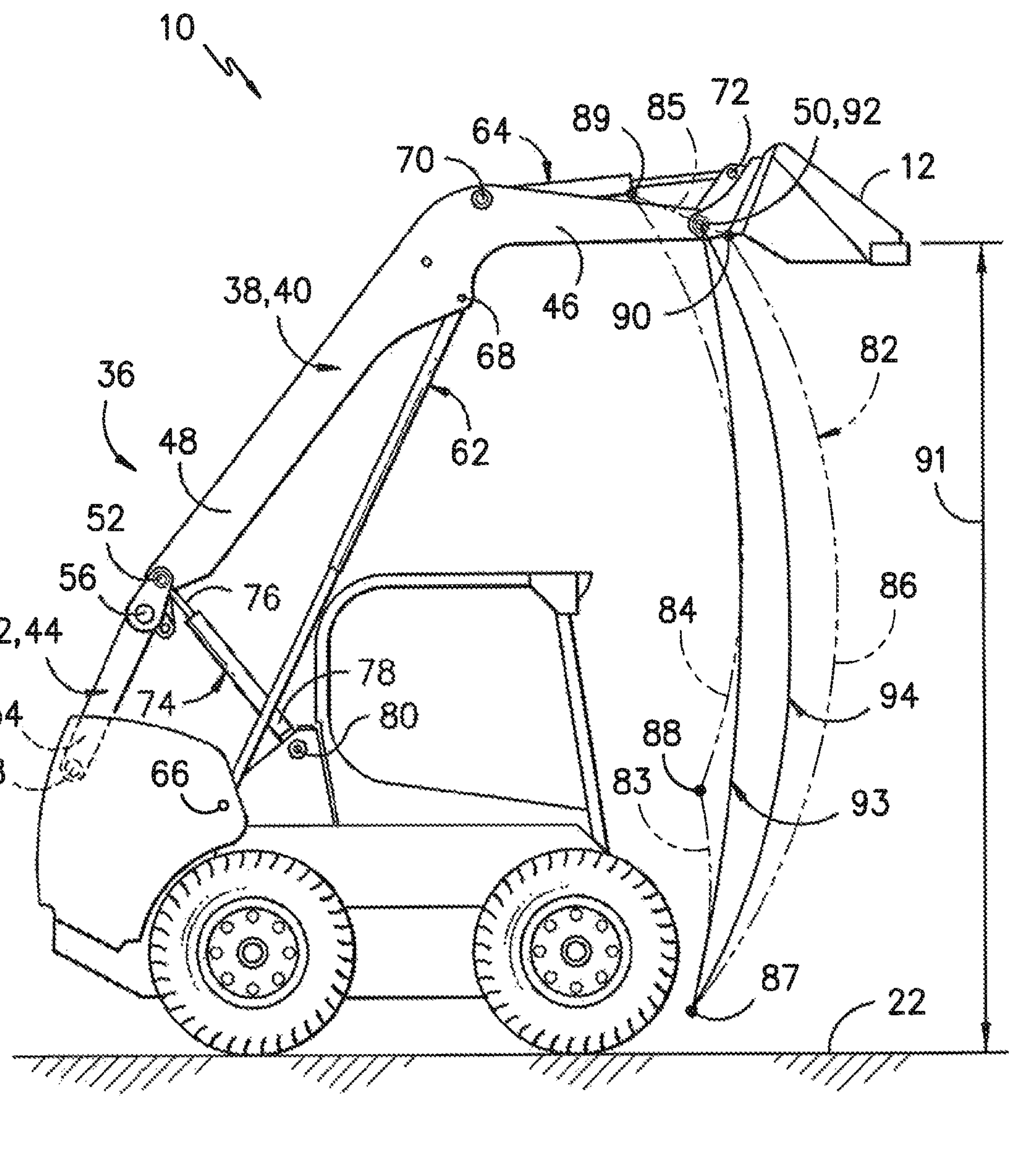
24
18

FIG. —3—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64
89
85
72
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70
12
46
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68
82
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48
62
91
52
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76
86
84
42,44
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94
74
54
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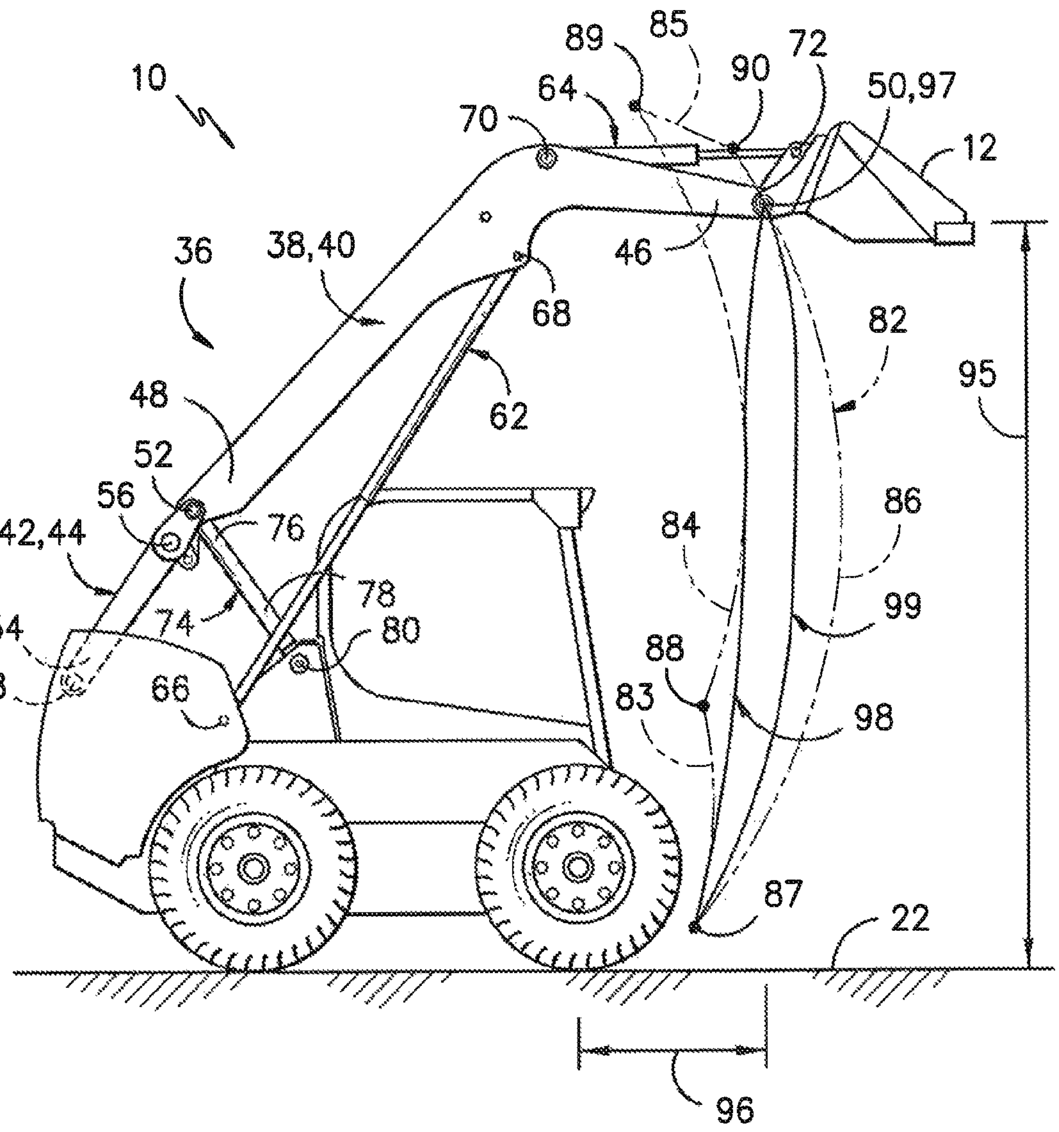
88
58
66
83
93
87
22

FIG. —4—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89
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12
36
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76
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86
78
74
99
54
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66
83
98
87
22
96

FIG. –5–

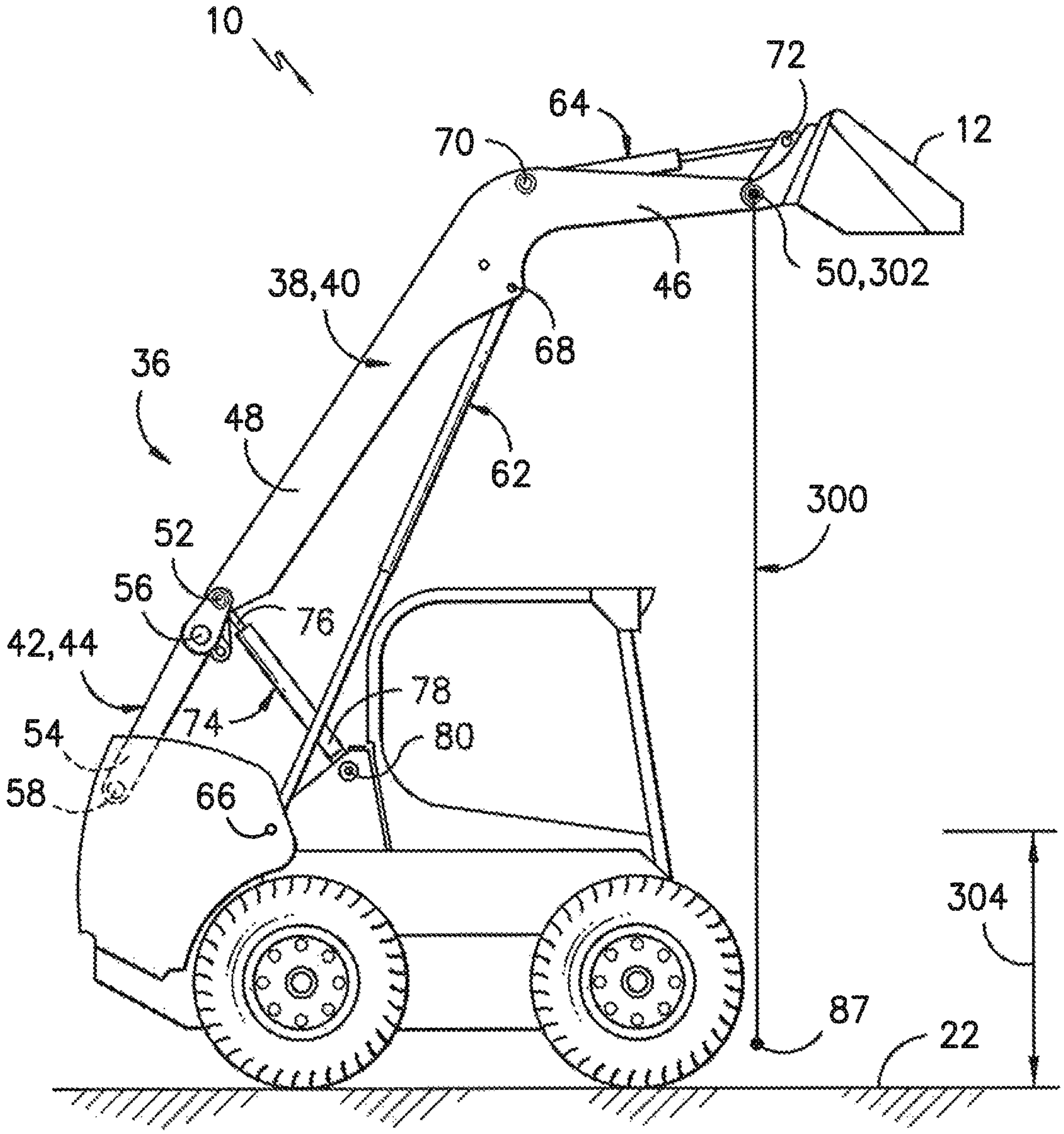
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FIG. -6-

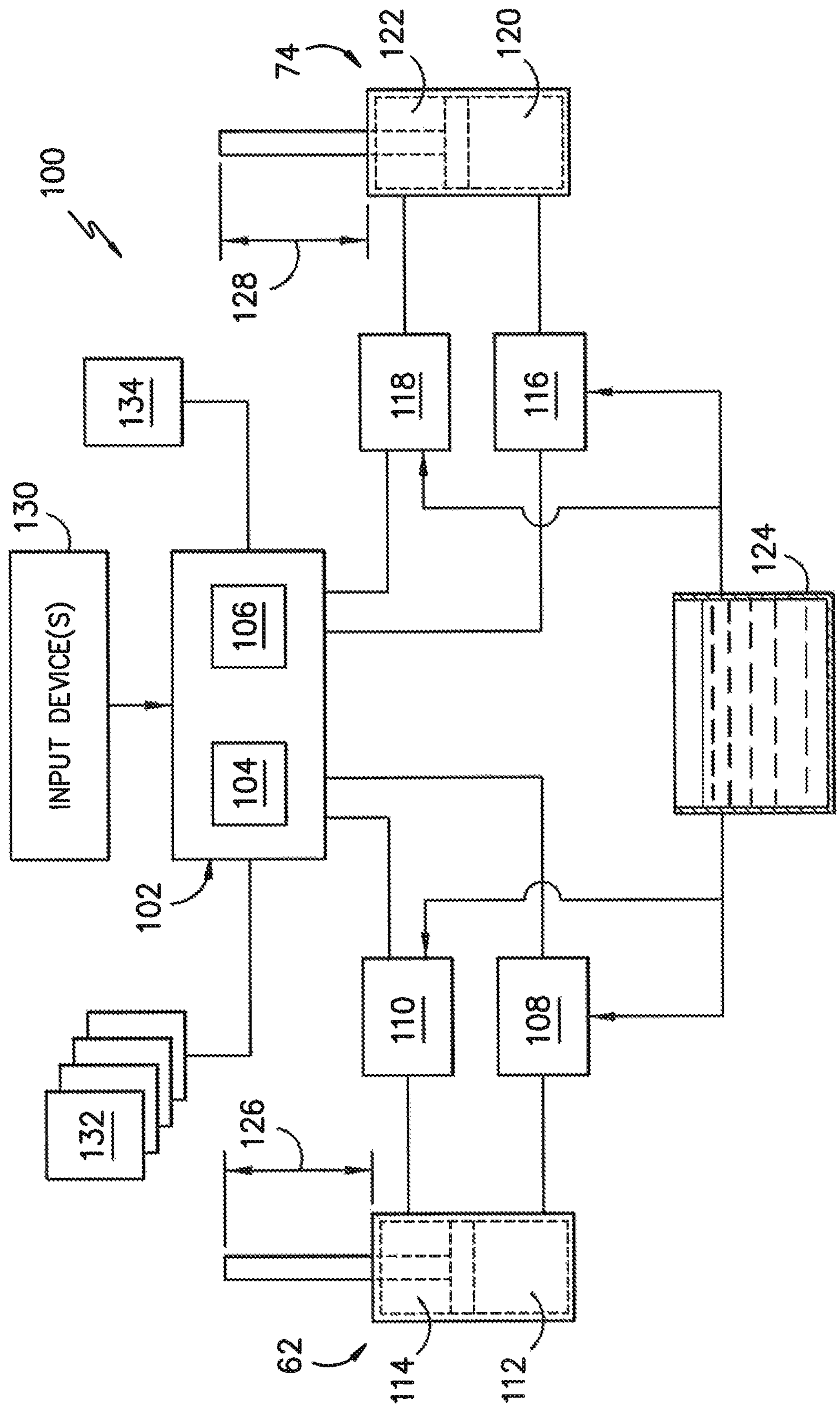
100
74
122
120
128
134
118
116
130
INPUT DEVICE(S)
106
104
124
102
110
108
132
126
62
114
112

FIG. –7–

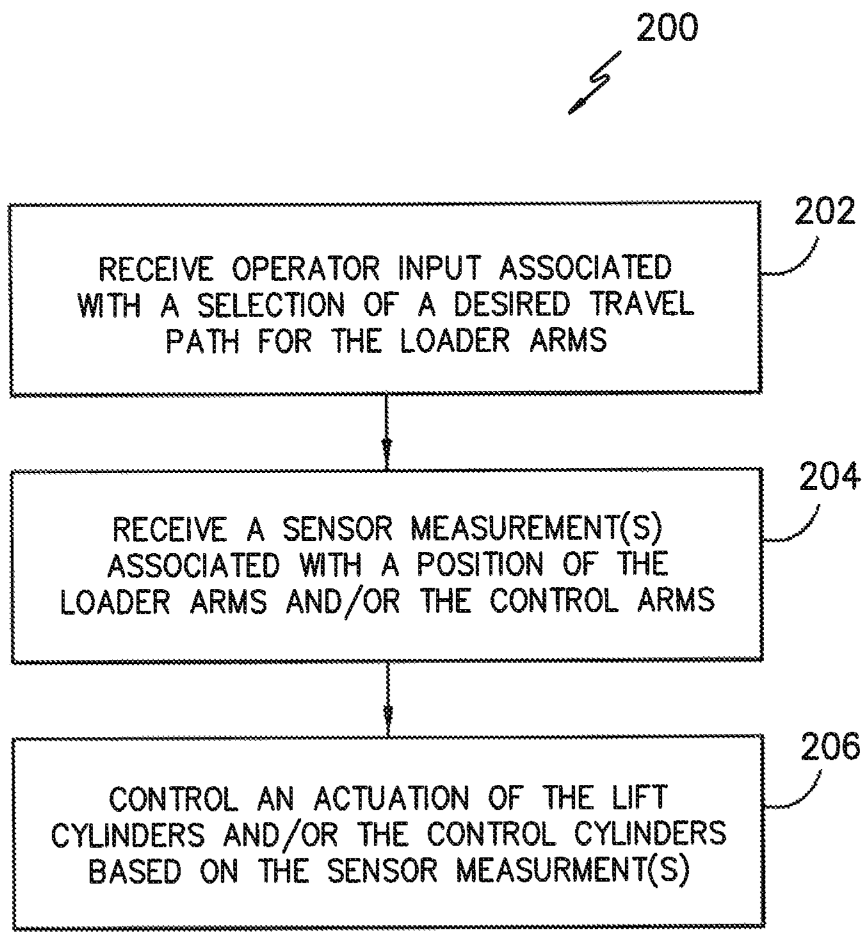
200
202
RECEIVE OPERATOR INPUT ASSOCIATED WITH A SELECTION OF A DESIRED TRAVEL PATH FOR THE LOADER ARMS
204
RECEIVE A SENSOR MEASUREMENT(S) ASSOCIATED WITH A POSITION OF THE LOADER ARMS AND/OR THE CONTROL ARMS
206
CONTROL AN ACTUATION OF THE LIFT CYLINDERS AND/OR THE CONTROL CYLINDERS BASED ON THE SENSOR MEASURMENT(S)

FIG. –8–

# LIFT ASSEMBLY FOR A WORK VEHICLE

## FIELD OF THE INVENTION

The present subject matter relates generally to work vehicles and, more particularly, to an improved lift assembly that allows for the loader arms of a work vehicle to be raised and/or lowered along a plurality of different travel paths.

## BACKGROUND OF THE INVENTION

Work vehicles having loader arms, such as skid steer loaders, telescopic handlers, wheel loaders, backhoe loaders, forklifts, compact track loaders and the like, are a mainstay of construction work and industry. For example, skid steer loaders typically include a pair of loader arms pivotally coupled to the vehicle's chassis that can be raised and lowered at the operator's command. The loader arms typically have an implement attached to their end, thereby allowing the implement to be moved relative to the ground as the loader arms are raised and lowered. For example, a bucket is often coupled to the loader arm, which allows the skid steer loader to be used to carry supplies or particulate matter, such as gravel, sand, or dirt, around a worksite.

Typically, each lift arm is coupled to the loader chassis at a given pivot point and is configured to be raised and lowered by a corresponding lift cylinder. As such, when the lift cylinders are extended and retracted, the loader arms may be raised and lowered, respectively, along a radial or arced path centered at the pivot point defined between the loader arms and the chassis. Such a radial lift path is often adequate for many loader applications but may not be the most desirable in applications where there is a need to alter the lift path of the loader arms to optimize performance for various tasks. For instance, to increase the rated operating capacity of the loader, it is desirable to have a substantially vertical lift path for the loader arms. As a result, manufacturers currently provide loader configurations that include complex four-bar linkages for the loader arms that allow for a substantially vertical lift path to be achieved. However, these loader configurations are restricted to lifting the loader arms along their single, pre-defined vertical lift path and, thus, the ability to alter the lift path of the loader arms for various tasks is lost.

Accordingly, an improved lift assembly for a work vehicle that allows for the loader arms of such vehicle to be raised and/or lowered along a plurality of different travel paths to allow for variations in the rated operating capacity, horizontal reach and/or cycle times associated with the loader arms would be welcomed in the technology.

## BRIEF DESCRIPTION OF THE INVENTION

Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

In one aspect, the present subject matter is directed to a lift assembly for a work vehicle. The lift assembly may generally include a loader arm extending between a forward end and a rear end and a control arm extending between a first end and a second end. The first end may be coupled to a chassis of the work vehicle at a first pivot point and the second end may be coupled to the rear end of the loader arm at a second pivot point. In addition, the lift assembly may include a lift cylinder coupled between the loader arm and the chassis and a control cylinder extending between an upper end and a lower end, with the upper end being coupled to the control arm and the lower end being coupled to the chassis at a third pivot point. Moreover, the first pivot point may be located rearward of the second pivot point when the control cylinder is at a fully retracted position.

In another aspect, the present subject matter is directed to a lift assembly for a work vehicle. The lift assembly may generally include a loader arm extending between a forward end and a rear end and a control arm extending between a first end and a second end. The first end may be coupled to a chassis of the work vehicle at a first pivot point and the second end may be coupled to the rear end of the loader arm at a second pivot point. In addition, the lift assembly may include a lift cylinder coupled between the loader arm and the chassis and a control cylinder extending between an upper end and a lower end, with the upper end being coupled to the control arm and the lower end being coupled to the chassis at a third pivot point. Moreover, the lift cylinder may be coupled to the chassis at a fourth pivot point that is positioned both vertically below and rearward of the third pivot point.

In a further aspect, the present subject matter is directed to a method for controlling a lift assembly of a work vehicle. The lift assembly may include a loader arm and a control arm, wherein the control arm extends between a first end coupled to a chassis of the work vehicle at a first pivot point and a second end coupled to the loader arm at a second pivot point. The method may generally include receiving an operator input associated with a selection of a desired travel path for the loader arm, receiving at least one sensor measurement associated with a position of at least one of the loader arm or the control arm and controlling an actuation of at least one of a lift cylinder or a control cylinder of the lift assembly based on the at least one sensor measurement such that a reference point defined on the loader arm is raised or lowered along the desired travel path, wherein the lift cylinder is coupled between the loader arm and the chassis and wherein the control cylinder extends between an upper end coupled to the control arm and a lower end coupled to the chassis at a third pivot point.

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

FIG. **1** illustrates a side view of one embodiment of a work vehicle in accordance with aspects of the present subject matter, particularly illustrating an implement of the work vehicle being located at its lowermost position relative to a driving surface of the vehicle;

FIG. **2** illustrates a rear perspective view of the work vehicle shown in FIG. **1**;

FIG. **3** illustrates a front perspective view of the work vehicle shown in FIG. **1**, particularly illustrating the implement after it has been raised from its lowermost position via a lift assembly of the vehicle;

FIG. **4** illustrates a side view of the work vehicle shown in FIG. **1** with the implement being raised relative to the vehicle's driving surface to a first location, particularly illustrating two suitable travel paths that may be used to raise the implement to the first location in accordance with aspects of the present subject matter;

FIG. **5** illustrates another side view of the work vehicle shown in FIG. **1** with the implement being raised relative to the vehicle's driving surface to a second location, particularly illustrating two suitable travel paths that may be used to raise the implement to the second location in accordance with aspects of the present subject matter;

FIG. **6** illustrates a further side view of the work vehicle shown in FIG. **1**, particularly illustrating one example of a straight vertical travel path along which the loader arms may be raised and lowered in accordance with aspects of the present subject matter;

FIG. **7** illustrates a schematic diagram of one embodiment of a control system for controlling a lift assembly of a work vehicle in accordance with aspects of the present subject matter; and

FIG. **8** illustrates a flow diagram of one embodiment of a method for controlling a lift assembly of a work vehicle in accordance with aspects of the present subject matter.

## DETAILED DESCRIPTION OF THE INVENTION

Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

In general, the present subject matter is directed to an improved lift assembly for a work vehicle. Specifically, in several embodiments, the lift assembly may include a pair of loader arms pivotally coupled to a corresponding pair of control arms, with each control arm being pivotally coupled, in turn, to the chassis of the work vehicle. In addition, the lift assembly may include a pair of lift cylinders for raising and lowering the loader arms and a pair of control cylinders for adjusting the position of a dynamic pivot point defined between the control arms and the loader arms. Specifically, by retracting and/or extending the control cylinders, the control arms may be pivoted about a fixed pivot point defined between the control arms and the chassis, thereby adjusting the relative position of the dynamic pivot point.

Such adjustments of the dynamic pivot point may allow for the travel path of the loader arms to be varied as the arms are raised and/or lowered relative to the ground via the lift cylinders. Thus, by carefully controlling the actuation of the control cylinders and the lift cylinders, the loader arms may be raised and/or lowered along a plurality of different travel paths, thereby allowing specific travel paths to be selected and/or tailored to the requirements of the work being performed. For instance, if increased lift capacity is required, the actuation of the control cylinders and the lift cylinders may be controlled in a manner that provides for the forward end of the loader arms (i.e., the end coupled to a suitable implement, such as a bucket) to be raised and/or lowered along a substantially vertical travel path. Alternatively, if increased reach and/or increased lift speed is required, the actuation of the control cylinders and lift cylinders may be controlled in a manner that provides for the forward end of the loader arms to be raised and/or lowered along a more radial or arcuate travel path. Moreover, the use of the control cylinders may also allow for the forward end of the loader arms to be raised and/or lowered along an absolute straight vertical travel path along at least a portion of the vertical distance defined between the vehicle's driving surface and the maximum lift height for the loader arms.



Referring now to FIGS. **1**-**3**, one embodiment of a work vehicle **10** is illustrated in accordance with aspects of the present subject matter. Specifically, FIG. **1** illustrates a side view of the work vehicle **10**, particularly illustrating an implement **12** of the work vehicle **10** being located at its lowermost position relative to a driving surface **22** of the vehicle **10**. Additionally, FIG. **2** illustrates a rear perspective view of the work vehicle **10** shown in FIG. **1** and FIG. **3** illustrates a front perspective of the work vehicle **10** after the implement **12** has been raised from its lowermost position. For purposes of description, the forward direction (indicated by arrow **14** in FIG. **1**) and the reverse direction (indicated by arrow **16** in FIG. **1**) will be referenced relative to a front end **18** and a rear end **20** of the work vehicle **10**. Thus, for example, a first location on the work vehicle **10** may be considered to be positioned rearward of a second location on the work vehicle **10** if the first location is positioned closer to the rear end **20** of the work vehicle **10** than the second location along a reference plane extending parallel to the driving surface **22**.

In the illustrated embodiment, the work vehicle **10** is configured as a skid steer loader. However, in other embodiments, the work vehicle **10** may be configured as any other suitable work vehicle known in the art, such as any other work vehicle including loader arms (e.g., telescopic handlers, wheel loaders, backhoe loaders, forklifts, compact track loaders and/or the like).

As shown, the work vehicle **10** includes a pair of front wheels **24**, a pair of rear wheels **26** and a chassis **28** coupled to and supported by the wheels **24**, **26**. An operator's cab **30** may be supported by a portion of the chassis **28** and may house various input devices for permitting an operator to control the operation of the work vehicle **10**. In addition, the work vehicle **10** may include an engine (not shown) and a hydrostatic drive unit (not shown) coupled to or otherwise supported by the chassis **28**.

It should be appreciated that various components of the work vehicle **10** will be described herein as being coupled to the chassis **28**. As used herein, a component may be "coupled to" the chassis **28** by being directly coupled to a component of the chassis **28** or by being indirectly coupled to a component of the chassis **28** (e.g., via a secondary component).

Moreover, as shown in FIGS. **1**-**3**, the work vehicle **10** may also include a lift assembly **36** for raising and lowering the implement **12** (e.g., a bucket, fork, blade and/or the like) relative to the driving surface **22** of the vehicle **10**. In several embodiments, the lift assembly **36** may include a pair of loader arms (e.g., a first loader arm **38** and a second loader arm **40**) pivotally coupled to the implement **12** and a corresponding pair of control arms (e.g., a first control arm **42** and a second control arm **44**) pivotally coupled between the loader arms **38**, **40** and the chassis **28**. Specifically, as shown in FIG. **1**, the loader arms **38**, **40** may each be configured to extend lengthwise between a forward end **46** and an aft end **48**, with the forward end **46** of each loader arm **38**, **40** being pivotally coupled to the implement **12** at a forward pivot point **50** and the aft end **48** of each loader arm **38**, **40** being pivotally coupled to its corresponding control arm **42**, **44** at a dynamic rear pivot point **52**. Similarly, each control arm **42**, **44** may extend between a first end **54** and a second end **56**, with the first end **54** being pivotally coupled to the chassis **28** at a fixed pivot point **58** and the second end **56** being pivotally coupled to the aft end **48** of the corresponding loader arm **38**, **40** at the dynamic pivot point **52**.

As particularly shown in FIG. **2**, in several embodiments, a connector arm **60** may be configured to extend perpendicularly between the control arms **42**, **44** in order to secure the control arms **42**, **44** to one another. For example, in one embodiment, the connector arm **60** may have a tube-like configuration and may be configured to be inserted through corresponding openings (not shown) defined in the control arms **42**, **44**. In such an embodiment, the connector arm **60** may be secured within the openings (e.g., by welding the portions of the connector arm **60** extending through the openings to the control arms **44**, **44**) in order to form a frame assembly comprised of the control arms **42**, **44** and the connector arm **60**. By securing the control arms **42**, **44** together via the connector arm **60**, it can be ensured that the control arms **42**, **44** are pivoted simultaneously about the fixed pivot point **58** as the loader arms **38**, **40** are being raised and/or lowered.

In addition, the lift assembly **36** may also include a pair of hydraulic lift cylinders **62** coupled between the chassis **28** and the loader arms **38**, **40** and a pair of hydraulic tilt cylinders **64** coupled between the loader arms **38**, **40** and the implement **12**. For example, as shown in the illustrated embodiment, each lift cylinder **62** may be pivotally coupled to the chassis at a lift pivot point **66** and may extend outwardly therefrom so to be coupled to its corresponding loader arm **38**, **40** at an intermediate attachment location **68** defined between the forward and aft ends **46**, **48** of each loader arm **38**, **40**. Similarly, each tilt cylinder **68** may be coupled to its corresponding loader arm **38**, **40** at a first attachment location **70** and may extend outwardly therefrom so as to be coupled to the implement **12** at a second attachment location **72**.

It should be readily understood by those of ordinary skill in the art that lift and tilt cylinders **62**, **64** may be utilized to allow the implement **12** to be raised/lowered and/or pivoted relative to the driving surface **22** of the work vehicle **10**. For example, the lift cylinders **62** may be extended and retracted in order to pivot the loader arms **38**, **40** upward and downwards, respectively, about the dynamic pivot point **52**, thereby at least partially controlling the vertical positioning of the implement **12** relative to the driving surface **22**. Similarly, the tilt cylinders **64** may be extended and retracted in order to pivot the implement **12** relative to the loader arms **38**, **40** about the forward pivot point **50**, thereby controlling the tilt angle or orientation of the implement **12** relative to the driving surface **22**.

Moreover, in several embodiments, the lift assembly **36** may also include a pair of control cylinders **74** for adjusting the relative location of the dynamic pivot point **52**, thereby allowing for the travel path of the loader arms **38**, **40** to be dynamically adjusted as the implement **12** is being raised and/or lowered relative to the drive surface **22**. Specifically, as shown in the illustrated embodiment, the control cylinders **74** may each be configured to extend between a top end **76** and a bottom end **78**, with the top end **76** of each control cylinder **74** being pivotally coupled to its corresponding control arm **42**, **44** at the dynamic pivot point **52** and the bottom end **78** being pivotally coupled to the vehicle's chassis **28** at a control pivot point **80**. Alternatively, the top end **76** of each control cylinder **74** may be coupled to the corresponding control arm **42**, **44** at any other suitable location along the arm's length, such as at a location between the dynamic pivot point **52** and the fixed pivot point **58**. Regardless, the control cylinders **74** may be extended and retracted in order to adjust the location of the dynamic pivot point **52** in a counter-clockwise direction or a clockwise direction, respectively, about the fixed pivot point **58**. Thus, by controlling the actuation or stroke length of the control cylinders **74**, the loader arms **38**, **40** may be raised and/or lowered along any number of different travel paths as the lift cylinders **62** as are used to adjust the position of the implement **12** relative to the driving surface **22**.

For example, FIG. **1** illustrates a bounded travel area **82** defining the potential area across which the forward pivot point **50** may be moved using the disclosed lift assembly **36**. Specifically, as shown in FIG. **1**, the travel area **82** is defined by a first boundary line **83**, a second boundary line **84**, a third boundary line **85** and a fourth boundary line **86**. The first and third boundary lines **83**, **85** generally define the range of movement for the loader arms **38**, **40** at the forward pivot point **50** when the control cylinders **74** are being actuated while the lift cylinders **62** are maintained at either their fully retracted position or their fully extended position. For example, when the forward pivot point **50** is located at the lowermost position within the bounded travel area **82** (i.e., at point **87**), the forward pivot point **50** may be moved along the first boundary line **83** to point **88** by simply actuating the control cylinders **74** from a fully retracted position (at point **87**) to a fully extended position (at point **88**) while maintaining the lift cylinders **62** at their fully retracted position. Similarly, the forward pivot point **50** may be moved along the third boundary line **85** from point **89** to point **90** by simply actuating the control cylinders **74** from a fully extended position (at point **89**) to a fully retracted position (at point **90**) while maintaining the lift cylinders **62** at their fully extended position.

Moreover, the second and fourth boundary lines **84**, **86** generally define the range of movement for the loader arms **38**, **40** at the forward pivot point **50** when the lift cylinders **62** are being actuated while the control cylinders **74** are maintained in either their fully extended position or their fully retracted position. For example, to move the forward pivot point **50** from point **88** to point **89**, the lift cylinders **62** may be actuated from a fully retracted position (at point **88**) to a fully extended position (at point **89**) while maintaining the control cylinders **74** at their fully extended position. Similarly, to move the forward pivot point **50** from point **87** to point **90**, the lift cylinders **62** may be actuated from a fully retracted position (at point **87**) to a fully extended position (at point **90**) while maintaining the control cylinders **74** at their fully retracted position. As such, it should be readily understood that, to move the forward pivot point **50** from the lowermost position defined within the bounded travel area **82** (i.e., at point **87**) to any other location on or within such area **82**, each control cylinder **74** may be either initially maintained at its fully retracted position (e.g., to raise the forward pivot point **50** along the fourth boundary line **86**) or initially extended outwardly from its fully retracted position (e.g., to initially move the forward pivot point **50** to any location rearward of the fourth boundary line **86**).

It should be appreciated that, in several embodiments, the positioning of the control arms **42**, **44** relative to the loader arms **38**, **40** and/or the relative positioning of the various pivot points **52**, **58**, **66**, **80** may be selected such that the desired travel area **82** is defined for the loader arms **38**, **40** at the forward pivot point **50**. For example, as shown in the illustrated embodiment, the location of the fixed pivot point **58** may be selected such that the pivot point **58** is positioned rearward of and vertically below the dynamic pivot point **52** when the control cylinders **74** are at their fully retracted positions. As such, each control arm **42**, **44** may be configured to be angled both forward and upward from its first end **54** to its second end **56** when the control cylinders **74** are at their fully retracted positions. Additionally, in one embodiment, the location of the fixed pivot point **58** may be selected such that the pivot point **58** is still positioned rearward of the dynamic pivot point **52** even when the control cylinders **74** are at their fully extended positions. Moreover, in several embodiments, the location of the control pivot point **80** for each control cylinder **74** may be selected such that the pivot point **80** is located both vertically above and forward of the lift pivot point **66** for each lift cylinder **62**. However, it should be appreciated that, in alternative embodiments, the positioning of the control arms **42**, **44** relative to the loader arms **38**, **40** and/or the relative positioning of the various pivot points **52**, **58**, **66**, **80** may be adjusted to provide any other suitable configuration that allows for the loader arms **38**, **40** to be raised and/or lowered along a plurality of different travel paths in a manner consistent with the disclosure provided herein.

Moreover, given the bounded travel area **82** shown in FIG. **1**, one of ordinary skill in the art should readily appreciate that any number of different travel paths may be achieved within such area **82** by selectively actuating the lift cylinders **62** and the control cylinders **74** as the loader arms **38**, **40** are being raised and/or lowered relative to the driving surface **22**. For example, as shown in FIG. **4**, it may be desirable for the implement **12** to be raised to a given height **91** above the vehicle's driving surface **22** (e.g., such that the forward pivot point **50** is located at point **92**). In such instance, the loader arms **38**, **40** may be directed along various different travel paths as the forward pivot point **50** is moved between point **87** and point **92**. For example, as shown in FIG. **4**, a substantially vertical travel path **93** may be defined between the points **87** and **92**, which may allow for the work vehicle **10** to have an increased lift capacity. Alternatively, a more radial or arced travel path **94** may be defined between the points **87** and **92**, which may allow for the implement **12** to be raised to the desired height **91** in a shorter amount of time than that required for the substantially vertical travel path **93**.

Another example of suitable travels paths that may be provided within the bounded travel area **82** is shown in FIG. **5**. As shown, it may be desirable for the implement **12** to be raised to a certain vertical height **95** while also being capable of extending outwardly a given horizontal distance **96** in order to increase the overall reach of the implement **12** (e.g., to point **97**). In such instance, similar to the example described above with reference to FIG. **4**, various different travel paths may be defined between point **87** and point **97**. For instance, as shown, a substantially vertical travel path **98** may defined between the points **87** and **97**, which may allow for increased lift capacity. Alternatively, a more radial or arced travel path **88** may be defined between points **87** and **97**, which may allow for the loader arms **38**, **40** to be raised and/or lowered in less time.

It should be appreciated that the various travel paths **93**, **94**, **98**, **99** shown in FIGS. **4** and **5** are simply illustrated to provide several examples of suitable travel paths that may be achieved using the disclosed lift assembly **36**. However, one of ordinary skill in the art should readily understand that any number of different travel paths may be defined within the bounded travel area **82** by altering the manner in which the control cylinders **74** and the lift cylinders **62** are actuated as the implement **12** is being raised and/or lowered relative to the driving surface **22**. In addition, it should be appreciated that, as an alternative to the forward pivot point **50**, the bounded travel area **82** for the loader arms **38**, **40** may be defined relative to any other suitable reference point or location along each loader arm **38**, **40**.

It should also be appreciated that, by adjusting one or more parameters associated with the lift cylinders **62** and/or the control cylinders **74** and/or by adjusting the relative positioning of the various pivot points **52**, **58**, **66**, **80**, the shape and/or size of bounded travel area **82** may be varied significantly. For instance, in a particular embodiment, the bounded travel area **82** may be expanded or shifted rearward such that the forward pivot point **50** may be moved along an absolute straight vertical travel path from the lowermost position **87**. An example of such a lift path is illustrated in FIG. **6**. As shown, the control cylinders **74** and the lift cylinders **62** may be controlled in a manner that allows the forward pivot point to be raised and lowered along a vertically straight path **300** extending between point **87** and point **302**. To achieve this vertical path **300**, the lift cylinders **62** may, in one embodiment, by configured such that each cylinder **62** is not in its fully retracted position when the forward pivot point **50** is located at the lowermost position **87** (i.e., such that the lift cylinders **62** may be further retracted at point **87**). Such a configuration may generally allow for the aft boundary of the bounded travel area (e.g., defined by the first and second boundary lines **83**, **84** shown in FIGS. **4** and **5**) to be shifted rearward, thereby accommodating the vertical travel path **300** shown in FIG. **6**. In such an embodiment, to begin raising the forward pivot point **50** upward from point **87** along the vertical path **300**, the lift cylinders **62** may be initially retracted towards their fully retracted position while the control cylinders **74** are extended until the forward pivot point **50** has reached a given height **304**. Thereafter, the lift cylinders **62** may be extended as the control cylinders **74** are controlled in a manner that allows the forward pivot point **50** to be lifted along the remainder of the vertical path **300**.

Additionally, it should be appreciated that, although the work vehicle **10** shown in FIGS. **1-6** has been described herein as including a pair of control cylinders **74** and a pair of lift cylinders **62**, the work vehicle **10** may, instead, include any number of control cylinders **74** and lift cylinders **62**. For instance, in one embodiment, the work vehicle **10** may only include a single control cylinder **74** and a single lift cylinder **62** for controlling the movement of the loader arms **38**, **40**. Alternatively, the work vehicle **10** may include a single control cylinder **74** together with a pair of lift cylinders **62** for controlling the movement of the loader arms **38**, **40** or vice versa.

Referring now to FIG. **7**, a schematic diagram of one embodiment of a control system **100** for controlling the disclosed lift assembly **36** is illustrated in accordance with aspects of the present subject matter. In general, the system **100** will be described herein with reference to the work vehicle **10** and lift assembly **36** described above with reference to FIGS. **1-6**. However, it should be appreciated by those of ordinary skill in the art that the disclosed system **100** may generally be utilized with work vehicles **10** having any another suitable vehicle configuration and/or any other suitable lift assembly configuration consistent with the disclosure provided herein.

As shown, the control system **100** may generally include a controller **102** configured to electronically control the operation of one or more components of the work vehicle **10**, such as the various hydraulic components of the work vehicle **10** (e.g., the lift cylinders **62**, the control cylinders **74** and/or the tilt cylinders **64**). In general, the controller **102** may comprise any suitable processor-based device known in the art, such as a computing device or any suitable combination of computing devices. Thus, in several embodiments, the controller **102** may include one or more processor(s) **104** and associated memory device(s) **106** configured to perform a variety of computer-implemented functions. As used herein, the term "processor" refers not only to integrated circuits referred to in the art as being included in a computer, but also refers to a controller, a microcontroller, a microcomputer, a programmable logic controller (PLC), an application specific integrated circuit, and other programmable circuits. Additionally, the memory device(s) **106** of the controller **102** may generally comprise memory element(s) including, but are not limited to, computer readable medium (e.g., random access memory (RAM)), computer readable non-volatile medium (e.g., a flash memory), a floppy disk, a compact disc-read only memory (CD-ROM), a magneto-optical disk (MOD), a digital versatile disc (DVD) and/or other suitable memory elements. Such memory device(s) **106** may generally be configured to store suitable computer-readable instructions that, when implemented by the processor(s) **104**, configure the controller **102** to perform various computer-implemented functions, such as the method **200** described below with reference to FIG. **8**. In addition, the controller **102** may also include various other suitable components, such as a communications circuit or module, one or more input/output channels, a data/control bus and/or the like.

It should be appreciated that the controller **102** may correspond to an existing controller of the work vehicle **10** or the controller **102** may correspond to a separate processing device. For instance, in one embodiment, the controller **102** may form all or part of a separate plug-in module that may be installed within the work vehicle **10** to allow for the disclosed system and method to be implemented without requiring additional software to be uploaded onto existing control devices of the vehicle **10**.

In several embodiments, the controller **102** may be configured to be coupled to suitable components for controlling the operation of the various cylinders **62**, **64**, **74** of the work vehicle **10**. For example, as shown in FIG. **7**, the controller **102** may be communicatively coupled to suitable valves **108**, **110** (e.g., solenoid-activated valves) configured to control the supply of hydraulic fluid to each lift cylinder **62** (only one of which is shown in FIG. **7**). Specifically, as shown in the illustrated embodiment, the system **100** may include a first lift valve **108** for regulating the supply of hydraulic fluid to a cap end **112** of each lift cylinder **62**. In addition, the system **100** may include a second lift valve **110** for regulating the supply of hydraulic fluid to a rod end **114** of each lift cylinder **62**. Moreover, the controller **102** may be communicatively coupled to suitable valves **116**, **118** (e.g., solenoid-activated valves) configured to regulate the supply of hydraulic fluid to each control cylinder **74** (only one of which is shown in FIG. **7**). For example, as shown in the illustrated embodiment, the system **100** may include a first control valve **116** for regulating the supply of hydraulic fluid to a cap end **120** of each control cylinder **74** and a second control valve **118** for regulating the supply of hydraulic fluid to a rod end **122** of each control cylinder **74**. Although not shown, it should be appreciated that the controller **102** may be similarly coupled to suitable valves for controlling the supply of hydraulic fluid to each tilt cylinder **64**.

During operation, hydraulic fluid may be transmitted to the PRVs **108**, **110**, **116**, **118** from a fluid tank **124** mounted on and/or within the work vehicle **10** (e.g., via a pump (not shown)). The controller **102** may then be configured to control the operation of each valve **108**, **110**, **116**, **118** in order to control the flow of hydraulic fluid supplied to each of the cylinders **62**, **74**. For instance, the controller **102** may be configured to transmit suitable control commands to the lift valves **108**, **110** in order to regulate the flow of hydraulic fluid supplied to the cap and rod ends **112**, **114** of each lift cylinder **62**, thereby allowing for control of a stroke length **126**, **128** of the piston rod associated with each cylinder **62**. Of course, similar control commands may be transmitted from the controller **102** to the control valves **116**, **118** in order to control a stroke length **128** of the control cylinders **74**. Thus, by carefully controlling the actuation or stroke length **126**, **128** of the lift and control cylinders **62**, **74**, the controller **102** may, in turn, be configured to automatically control the manner in which the loader arms **38**, **40** are raised and lowered relative to the vehicle's driving surface **22**, thereby allowing the controller **102** to manipulate the travel path of the loader arms **38**, **40** as desired.

Additionally, as shown in FIG. **7**, the controller **102** may be communicatively coupled to one or more input devices **130** for providing operator inputs to the controller **102**. Such input device(s) **130** may generally correspond to any suitable input device(s) (e.g., a control panel, one or more buttons, levers and/or the like) housed within the operator's cab **30** that allows for operator inputs to be provided to the controller **102**. For example, in a particular embodiment, the input device(s) **130** may correspond to a lever(s) and/or any other input device(s) that allows for the operator to transmit suitable operator inputs for manually controlling the position of the loader arms **38**, **40** and/or implement **12**. In response to such input, the controller **102** may transmit suitable control signals to the appropriate valves in order to control the actuation of the corresponding cylinders. Moreover, as will be described in greater detail below, in several embodiments, a plurality of pre-defined travel paths may be stored within the controller's memory **106**, such as the travel paths **93**, **94**, **98**, **99** shown in FIGS. **4-6**. In such embodiments, the input device(s) **130** may correspond to suitable buttons and/or any other input device(s) that allow for the operator to transmit a suitable operator input(s) corresponding to a selection of one of the pre-defined travel paths. Upon receipt of such input(s), the controller **102** may then transmit suitable control signals to the appropriate valves in order to control the corresponding cylinders in a manner that causes the loader arms **38**, **40** to be raised and/or lowered along the selected travel path.

Moreover, as shown in FIG. **7**, the controller **102** may be communicatively coupled to one or more position sensors **132** for monitoring the position(s) and/or orientation(s) of the loader arms **38**, **40** and/or the control arms **42**, **44**. In several embodiments, the position sensor(s) **132** may be configured to monitor the degree of actuation of the lift and/or control cylinders **62**, **74**, which may provide an indication of the position and/or orientation of the corresponding loader arms **38**, **40** and/or control arms **42**, **44**. For instance, the position sensor(s) **132** may correspond to one or more rotary position sensors, linear position sensors and/or the like associated with and/or coupled to the piston rod(s) or other movable components of the cylinders **62**, **74** in order to monitor the travel distance of such components. In another embodiment, the position sensor(s) **122** may correspond to one or more non-contact sensors, such as one or more proximity sensors, configured to monitor the change in position of such movable components of the cylinders **62**, **74**. In a further embodiment, the position sensor(s) may correspond to one or more flow sensors configured to monitor the fluid into and/or out of each cylinder **62**, **74**, thereby providing an indication of the degree of actuation of such cylinder **62**, **74** and, thus, the location of the corresponding loader arms **38**, **40** and/or control arms **42**, **44**.

In other embodiments, the position sensor(s) **132** may correspond to any other suitable sensor(s) that is configured to provide a measurement signal associated with the position and/or orientation of the loader arms **38**, **40** and/or control arms **42**, **44**. For example, a transmitter(s) may be coupled to a portion of one or both of the loader arms **38**, **40** and/or one or both of the control arms **42**, **44** that transmits a signal indicative of the height/position and/or orientation of such arm(s) **38**, **40**, **42**, **44** to a receiver disposed at another location on the vehicle **10**.

By monitoring the position and/or orientation of the loader arms **38**, **40** and/or control arms **42**, **44** using the measurement signals provided by the sensor(s) **132**, the controller **102** may be configured to regulate the operation of the lift and/or control cylinders **62**, **74** in a manner that provides for extremely accurate control of the disclosed lift assembly **36**. This may be particularly advantageous in instances in which the operator has requested that the loader arms **38**, **40** be raised and/or lowered along a selected travel path. For example, upon the receipt of an operator input selecting a given travel path, the controller **102** may verify the exact position of the loader arms **38**, **40** and/or control arms **42**, **44** using the sensor measurements. Thereafter, the controller **102** may automatically adjust the position of the loader arms **38**, **40** and/or control arms **42**, **44**, if necessary, in order to properly position the loader arms relative to the selected travel path (e.g., by moving the loader arms **38**, **40** and/or control arms **42**, **44** such that the forward pivot point **50** is positioned on the selected travel path). Moreover, the controller **102** may be configured to continuously monitor the position of the loader arms **38**, **40** and/or control arms **42**, **44** as the lift and/or control cylinders **62**, **74** are being actuated in order to ensure that the actual travel path taken by the loader arms **38**, **40** corresponds to the selected travel path.

It should be appreciated that the controller **102** may also be communicatively coupled to any other suitable sensors for monitoring one or more operating parameters of the work vehicle **10**. For example, in a particular embodiment, the controller **102** may be coupled to one or more load sensors **134** for monitoring the load weight of any external loads applied through the loader arms **38**, **40** via the implement **12**. Such load monitoring may assist the controller **102** in determining whether an operator-selected travel path is appropriate given the current loading conditions of the work vehicle **10**. For example, if the operator selects a radial travel path for raising the implement **12** to a given height above the driving surface **22**, the controller **102** may be configured to utilize the load measurements provided by the sensor(s) **134** to determine whether the operator-selected path or a different travel path should be used to maintain stability of the work vehicle **10**. For instance, if the load weight exceeds a given threshold, the controller **102** may determine that a more vertical travel path should be used to raise the implement to the selected height in order to avoid vehicle tipping. In such instance, the controller **102** may be configured to automatically adjust the travel path used for the loader arms **38**, **40** to the more appropriate travel path. In addition, or as an alternative thereto, the controller **102** may be configured to provide the operator with a notification (e.g., an audible or visual notification) that the selected travel path is not appropriate given the current operating conditions.

Referring now to FIG. **8**, a flow diagram of one embodiment of a method **200** for controlling a lift assembly of a work vehicle is illustrated in accordance with aspects of the present subject matter. In general, the method **200** will be described with reference to the work vehicle **10**, lift assembly **36** and system **100** described above with reference to FIGS. **1-8**. However, it should be appreciated by those of ordinary skill in the art that the disclosed method **200** may generally be utilized to control any suitable lift assembly included within a work vehicle having any suitable configuration and/or any suitable control system. In addition, although FIG. **8** depicts steps performed in a particular order for purposes of illustration and discussion, the methods discussed herein are not limited to any particular order or arrangement. One skilled in the art, using the disclosures provided herein, will appreciate that various steps of the methods disclosed herein can be omitted, rearranged, combined, and/or adapted in various ways without deviating from the scope of the present disclosure.

As shown in FIG. **8**, at (**202**), the method **200** includes receiving an operator input associated with a selection of a desired travel path for the loader arms of the work vehicle. For example, as indicated above, one or more pre-defined travel paths may be stored within the controller's memory **106**. In such an embodiment, the input device(s) **130** provided within the vehicle's cab **20** may be used to transmit a suitable operator input(s) to the controller **102** that is associated with the selection of one of the pre-defined travel paths.

In addition to such pre-defined travel paths, or as an alternative thereto, one or more customized travel paths may be created and stored within the controller's memory **106**. For example, in one embodiment, a control panel of the work vehicle **10** may provide a means (e.g., a display with a suitable operator interface) for allowing an operator to define a customized travel path for the loader arms **38**, **40**, such as by creating any suitable travel path extending within the bounded travel area **82** associated with the disclosed lift assembly **36**. In such an embodiment, the customized travel path may be stored within the controller memory **106** and may be subsequently selected by the operator as the desired travel path to be executed by the controller **102**.

Additionally, at (**204**), the method **200** includes receiving at least one sensor measurement associated with a position of the loader arms and/or the control arms of the work vehicle. For example, as indicated above, the controller **102** may be communicatively coupled to one or more position sensors **132** for monitoring the position of the loader arms **38**, **40** and/or the control arms **42**, **44**. Thus, based on the signals provided by the sensor(s) **132**, the controller **132** may be configured to accurately determine the position of the loader arms **38**, **40** and/or the control arms **42**, **44**.

Moreover, at (**206**), the method **200** includes controlling an actuation of the lift cylinders and/or the control cylinders based on the sensor measurement(s) such that a reference point(s) defined on the loader arms is raised or lowered along the desired travel path selected by the operator. Specifically, as indicated above, the controller **102** may be configured to control the actuation or stroke length **126**, **128** of the lift cylinders **38**, **40** and/or the control cylinders **40**, **42** in order to achieve a plurality of different travel paths within a given travel area **82** associated with the disclosed lift assembly **36**. Accordingly, upon receipt of the operator's selection, the controller **102** may control the actuation of the lift cylinders **38**, **40** and/or the control cylinders **40**, **42** in a manner that causes a given reference point on the loader arms (e.g., the forward pivot point **50**) to be raised or lowered along the desired travel path. In doing so, the controller **102** may be configured to utilize the sensor measurements in order to move the reference point to a location on the desired travel path and/or to verify that the reference point is being moved along the desired travel path as it is being raised or lowered.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

**1**. A lift assembly for a work vehicle, the lift assembly comprising:

a loader arm extending between a forward end and a rear end;

a control arm extending between a first end and a second end, the first end being coupled to a chassis of the work vehicle at a first pivot point and the second end being coupled to the rear end of the loader arm at a second pivot point;

a lift cylinder coupled between the loader arm and the chassis, the lift cylinder being coupled to the loader arm at a location between its forward and rear ends;

a control cylinder extending between an upper end and a lower end, the upper end being coupled to the control arm and the lower end being coupled to the chassis at a third pivot point;

wherein the first pivot point is located rearward of the second pivot point when the control cylinder is at a fully retracted position,

wherein the upper end of the control cylinder is coupled to the loader arm at the second pivot point such that the control arm and the control cylinder are both coupled to the loader arm at a common pivot point.

**2**. The lift assembly of claim **1**, wherein a position of the second pivot point is adjusted when the control cylinder is retracted or extended.

**3**. The lift assembly of claim **1**, wherein the control cylinder is configured to be maintained at the fully retracted position or extended from the fully retracted position when the loader arm is initially raised from a lowermost position.

**4**. The lift assembly of claim **1**, wherein the lift cylinder is coupled to the chassis at a fourth pivot point, the fourth pivot point being positioned at a location vertically below and rearward of the third pivot point.

**5**. The lift assembly of claim **1**, wherein the third pivot point is located vertically above and forward of the first pivot point.

**6**. The lift assembly of claim **1**, further comprising a controller communicatively coupled to the lift cylinder and the control cylinder, the controller being configured to control an actuation of at least one the lift cylinder or the control cylinder such that a reference point defined on the loader arm is moved along a travel path defined within a travel area associated with the lift assembly.

**7**. The lift assembly of claim **6**, further comprising at least one position sensor communicatively coupled to the controller for monitoring a position of at least one of the loader arm or the control arm, the controller being configured to control the actuation of the at least one the lift cylinder or the control cylinder based on signals received from the at least one position sensor such that the reference point is moved along the travel path.

**8**. A lift assembly for a work vehicle, the lift assembly comprising:

a loader arm extending between a forward end and a rear end;

a control arm extending between a first end and a second end, the first end being coupled to a chassis of the work vehicle at a first pivot point and the second end being coupled to the rear end of the loader arm at a second pivot point;

a lift cylinder coupled between the loader arm and the chassis, the lift cylinder being coupled to the loader arm at a location between its forward and rear ends;

a control cylinder extending between an upper end and a lower end, the upper end being coupled to the control arm and the lower end being coupled to the chassis at a third pivot point;

wherein the lift cylinder is coupled to the chassis at a fourth pivot point that is positioned both vertically below and rearward of the third pivot point; and

wherein the control cylinder is configured to either be maintained at a fully retraced position or extended outwardly from the fully retracted position as the loader arm is initially being raised from a lowermost position.

**9**. The lift assembly of claim **8**, wherein the first pivot point is located rearward of and vertically below the second pivot point when the control cylinder is at a fully retracted position such that the control arm extends both vertically upward and forward from its first end to its second end when the control cylinder is at the fully retracted position.

**10**. The lift assembly of claim **8**, wherein the upper end of the control cylinder is coupled to the control arm at the second pivot point.

**11**. The lift assembly of claim **8**, wherein the third pivot point is located vertically above and forward of the first pivot point.

**12**. The lift assembly of claim **8**, further comprising a controller communicatively coupled to the lift cylinder and the control cylinder, the controller being configured to control an actuation of at least one the lift cylinder or the control cylinder such that a reference point defined on the loader arm is moved along a travel path defined within a travel area associated with the lift assembly.

**13**. The lift assembly of claim **12**, further comprising at least one position sensor communicatively coupled to the controller for monitoring a position of at least one of the loader arm or the control arm, the controller being configured to control the actuation of the at least one the lift cylinder or the control cylinder based on signals received from the at least one position sensor such that the reference point is moved along the travel path.

**14**. A method for controlling a lift assembly of a work vehicle, the lift assembly including a loader arm and a control arm, the control arm extending between a first end coupled to a chassis of the work vehicle at a first pivot point and a second end coupled to the loader arm at a second pivot point,

receiving, with a computing device, an operator input associated with a selection of a desired travel path for the loader arm;

receiving, with the computing device, at least one sensor measurement associated with a position of at least one of the loader arm or the control arm;

controlling, with the computing device, an actuation of at least one of a lift cylinder or a control cylinder based on the at least one sensor measurement such that a reference point defined on the loader arm is raised or lowered along the desired travel path, the lift cylinder being coupled between the loader arm and the chassis, the control cylinder extending between an upper end coupled to the control arm and a lower end coupled to the chassis at a third pivot point; and

wherein the upper end of the control cylinder is coupled to the loader arm at the second pivot point such that the control arm and the control cylinder are both coupled to the loader arm at a common pivot point.

**15**. The method of claim **14**, wherein controlling the actuation of the at least one the lift cylinder or the control cylinder based on the at least one sensor measurement comprises controlling the actuation of the control cylinder such that the control cylinder is maintained at a fully retracted position or is extended from the fully retracted position when the loader arm is initially raised from a lowermost position.

**16**. The method of claim **14**, wherein the desired travel path corresponds to a straight vertical path.

**17**. The method of claim **14**, wherein controlling the actuation of the at least one the lift cylinder or the control cylinder based on the at least one sensor measurement comprises controlling the actuation of the at least one the lift cylinder or the control cylinder such that a location of second pivot point is pivoted about the first pivot point.

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